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(71) Applicant
Rolls-Royce plc

(Incorporated in the United Kingdom)

65 Buckingham Gate, London, SW1E 6AT, United Kingdom

(72) Inventor
Andrew Keith Wilson

(74) Agent and/or Address for Service
T C Bird & V J Jennings
Rolls-Royce plc, Patents Department, PO Box 31, Moor Lane, Derby, DE2 8BJ, United Kingdom

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(54) Turbine balancing system

(57) A turbine balancing system uses a set of deadweighing scales 10 providing a mass readout signal directly to a computer 12 which stores them in memory 12A. When all of the blades for a turbine have been weighed the computer calculates the positions they must be placed in on the turbine disc in order to produce a balanced turbine. The information is supplied to a printer 14 or a VDU. The computer 12 can be supplied initially via a keyboard 13 or a bar code reader with data representing the amount by which the turbine disc is out of balance.

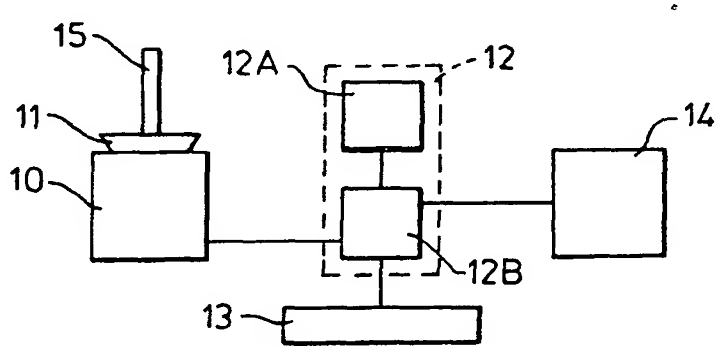

Fig.3.

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At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

Fig.1.

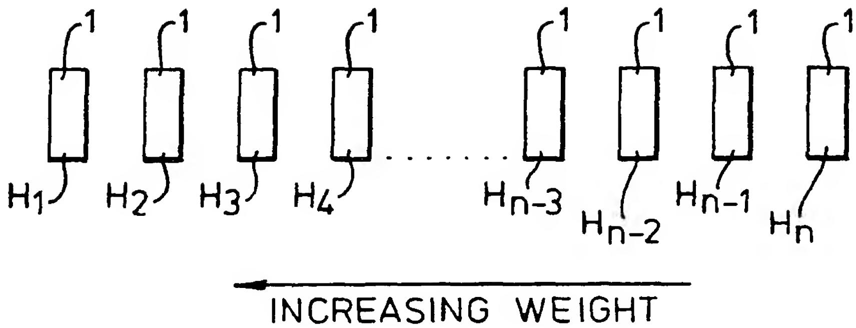


Fig. 2.

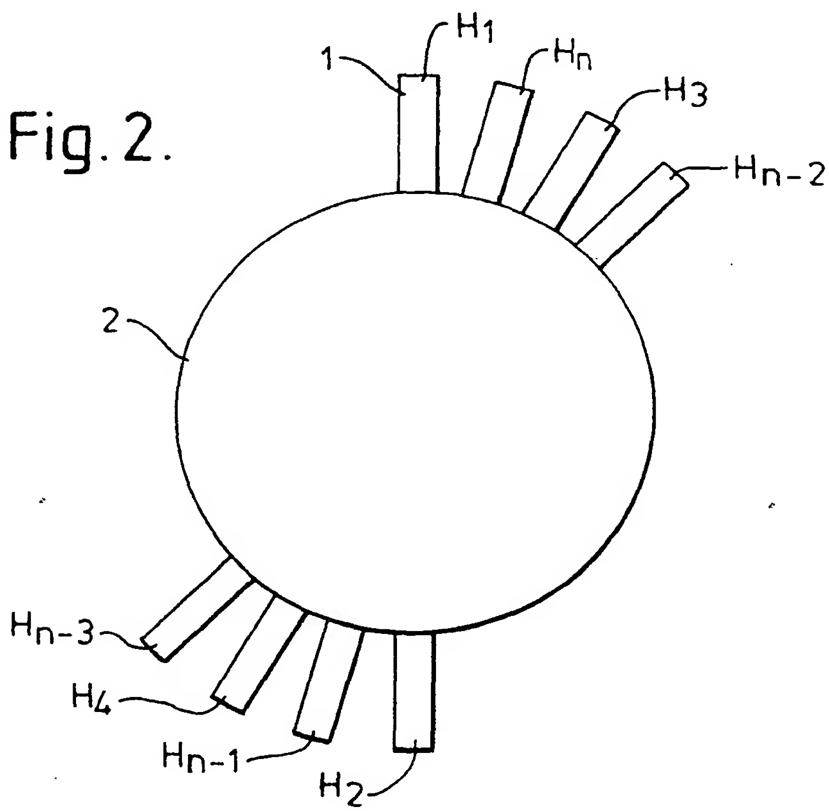
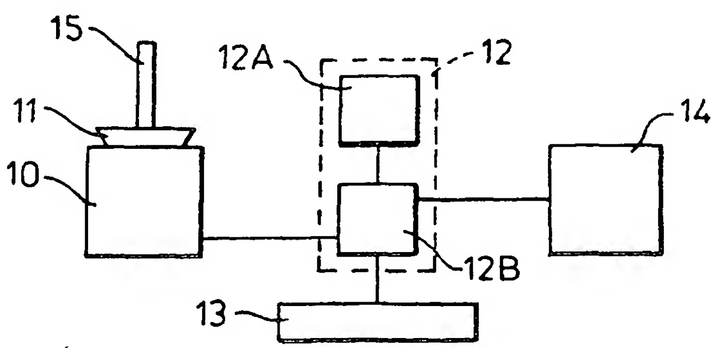


Fig.3.



TURBINE BALANCING SYSTEM

This invention relates to a turbine balancing system, particularly for balancing a gas turbine.

In gas turbines it is necessary to ensure that the turbine is correctly balanced. This can be done by attaching balance weights to the turbine. However, in gas turbines comprising a central disc and a plurality of separate turbine blades secured to the outer edge of the disc there are unavoidable random variations in the weight and centre of gravity of the blades due to manufacturing tolerances and it is generally possible to arrange the positions of the blades around the disc so that these variations interact to balance the turbine, so avoiding the need to use separate balance weights.

However, balancing the turbine in this way is a time consuming task requiring expensive equipment.

Referring to figure 1, in order to balance a turbine a set of turbine blades 1 are individually weighed and their weights recorded, generally by being written on the blade. The blades 1 are then laid out in order of weight as shown in figure 1, where H is the heaviest blade, H_2 the next heaviest and so on until H_n, the lightest blade is reached, 'n' being the number of blades on the turbine. A turbine can have 78 or more blades 1, so these are not trivial tasks, they require a large amount of time and there is considerable scope for error.

The blades 1 are then assembled on a turbine disc 2 in an order based on their relative weights. The heaviest blade H_1 is attached first, then the second heaviest blade H_2 is attached opposite H_1. The lightest blade H_n

is then attached adjacent to H_1 in the clockwise direction and the second lightest blade H_{n-1} is attached adjacent to H_2 in the clockwise direction. The third and fourth heaviest blades, H_3 and H_4 are then attached adjacent H_n and H_{n-1} respectively and the third and fourth lightest blades H_{n-2} and H_{n-3} are attached adjacent H_3 and H_4. This attachment sequence is followed around the whole of the disc 2.

The assembled turbine is then placed on a balance machine and checked by rotating it at speed and measuring the forces produced by any offset of the centre of mass of the turbine from its intended axis of rotation. The balance machine will inform the assembler of the direction and size of the out of balance vector. If this vector is larger than the acceptable limit some of the blades must be exchanged and the turbine placed on the balance machine again. The assembler must use his experience to decide which blades to exchange in order to reduce the out of balance vector to an acceptable level and it may take a number of such exchanges to do this.

In some cases it is possible to simply remove and exchange two turbine blades without taking the turbine off the balance machine, but it is often necessary, especially in turbines with interlocking blades, to remove the turbine from the balance machine and place it on a special jig before any blades can be removed.

Balance machines are very large and expensive pieces of equipment so turbine balancing can only be carried out at relatively small number of fixed instilations.

In many cases it is necessary to send turbines needing blade replacement back to the manufacturer in another country simply because the user does not have turbine

balancing facilities.

It has been proposed that turbine balancing could be carried out by measuring the moments of each blade individually and then calculating which arrangement of blades will produce an acceptable resultant moment. Although this overcomes the need for a balance machine it requires the use of a moment measuring machine, which is again expensive and requires careful setting in position.

This invention was intended to produce a turbine balancing system at least partially overcoming these problems.

This invention provides a turbine balancing system comprising a set of deadweighing scales arranged to supply signals describing the mass placed on the scales to a processor, the processor being linked to a memory device and a data output device and programmed so that when a plurality of turbine blades are placed one after another on the scales signals describing their mass values are stored in the memory device until a specific number of blades have been weighed, whereupon the processor calculates the positions in which the blades must be placed on a turbine disc to produce a balanced turbine and then reads out this information on the data output device.

It has been realised that in many turbines the variation in the position of the centre of gravity of the turbine blades is not significant and only the variations in the blade mass need to be taken into account in order to balance the turbine. As a result the use of a moment measuring system is unnecessary and the task of calculating the necessary blade positions can be

simplified. An integrated system in which deadweighing scales supply mass data directly to a processing system removes the possibility of data transcription errors causing an unbalanced turbine to be produced.

A turbine balancing system employing the invention will now be described by way of example only with reference to the accompanying diagrammatic figures in which;

Figure 3 shows a turbine balancing system according to the invention.

Referring to figure 3 a turbine balancing system comprises a set of deadweighing scales 10 with a top pan 11. The scales 10 are linked to send data to a computer 12 including a data storage device 12A and a processor 12B. The computer 12 also receives data from a keyboard 13 and is connected to a printer 14.

In order to balance a turbine the number of blades on the turbine is entered into the computer 12 using the keyboard 13. Then each blade 15 in turn is weighed on the scales 10, which sends a signal giving the weight of the blade 15 to the computer 12 which stores it in the data storage device 12A, and then marked temporarily with an identifying number. The first blade 15 to be weighed being numbered 1, the second being numbered 2 and so on.

When a number of blades 15 equal to the number of blades on the turbine have been weighed the processor 12B uses the information in the data storage device 12A to calculate the sequence in which they must be placed on the disc to produce an acceptable resultant moment.

The computer does this by calculating the out of balance

moment of the blades 15 in their initial random distribution. It then swaps two blades 15 at random and calculates the new moment, if it is higher it goes back to the original distribution, if lower it keeps the new diestribution. It then swaps another pair and repeats the process. This sequence is repeated until a distribution is found where no exchange of blades produces a lower moment.

This information is supplied to the user in the form of a printout from the printer 14 showing the number assigned to the blades 15 on weighing and their new order. For example, that working working clockwise, the first blade should be no 12, the second no 3 and so on.

If the turbine blades cannot be arranged to produce a balanced turbine the processor prints out a message saying this on the printer 14. A different selection of blades will then be made from the stock of blades.

If the disc itself is out of balance the amount and direction of its out of balance vector is permanently recorded on the disc. This data can then be supplied to the computer 12 at the start of the balancing operation, using the keyboard 13, and the processor 12B can calculate the necessary blade positions to produce an acceptable resultant moment including the effect of the unbalance of the disc 2. In this case the print out showing the sequence in which the blades 15 must be placed on the disc must also identify where on the disc the first blade in the sequence should be placed.

The numbers identifying the blades 15 could of course be placed on tags or labels attached to the blades 15 rather than being directly placed on the blades, similarly the direction and size of any out of balance

vector produced by the disc could be contained in any document associated with the disc rather than being recorded on the disc itself.

The keyboard could be replaced with some other manual data inputting device, such as a bar code reader.

The printer could be replaced by any other data readout device, such as a VDU.

CLAIMS

1 A turbine balancing system comprising a set of deadweighing scales arranged to supply signals describing the mass placed on the scales to a processor, the processor being linked to a memory device and a data output device and programmed so that when a plurality of turbine blades are placed one after another on the scales signals describing their mass values are stored in the memory device until a specific number of blades have been weighed, whereupon the processor calculates the positions in which the blades must be placed on a turbine disc to produce a balanced turbine and then reads out this information on the data output device.

2 A turbine balancing system as claimed in claim 1 in which the processor is also linked to a keyboard and the keyboard is used to tell the processor the specific number of blades to be weighed.

3 A turbine balancing system as claimed in claim 2 in which the keyboard is also used to supply the processor with data giving the out of balance vector of the turbine disc.

4 A turbine balancing system substantially as shown in or as described with reference to figure 3 of the accompanying drawings.

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